

### **4.3 Implications of Current Loadings of Level I Pesticides in the Great Lakes**

In previous sections, we have discussed the fate and transport, sources, and current concentrations of the Level I pesticides throughout the Great Lakes system. However, while important in terms of monitoring and tracking the gradual elimination of these compounds from the environment, these data do not provide a perspective regarding the environmental significance of these compounds. The purpose of this section is to evaluate the current levels with regard to health effects or other environmental consequences to determine the potential implications of the residual contamination.

Due to the variation in data availability and quality among the various chemicals, a formal risk assessment was not considered appropriate for the purpose of this report. Adverse effects to humans and ecological receptors associated with the Level I pesticides are summarized. Finally, current concentrations are compared to available benchmark values to determine the potential for adverse effects to be associated with conditions in the Great Lakes.

#### ***4.3.1 Human and Ecological Health Effects***

Persistent organic pollutants are, by definition, organic compounds that are highly resistant to degradation by biological, photolytic, or chemical means. They typically have low water solubility and high lipid solubility, leading to their propensity to pass readily through biological membranes and accumulate in fat deposits. These compounds have been associated with significant environmental impacts in a wide range of species and at virtually all trophic levels. Chronic toxicity is of particular concern due to the long half-lives associated with most of these chemicals.

In humans, chronic exposures to the Level I pesticides have been associated with effects to the reproductive, immune and endocrine systems (EPA, 1997d; Ritter et al., 1995). Neurological and behavioral effects have also been noted (EPA, 1997d; Ritter et al., 1995). Acute exposures to these compounds have been demonstrated to cause a variety of systemic, neurological and behavioral symptoms including headache, dizziness, nausea, vomiting, irritability, confusion, ataxia and general malaise (USDHHS, 1993, 1994a,b, 1995; Ritter et al., 1995; EPA, 1997d). In addition, chlordane and DDT may be associated with an increase in cerebrovascular disease (Ritter et al., 1995). All of these pesticides have been determined to be probable carcinogens based on animal studies; there are no definitive human data regarding the carcinogenicity of these compounds (EPA, 1997d). For example, DDT may be associated with liver and biliary cancer, however, confounding factors in the study were not fully accounted for (Ritter et al., 1995). A recent study in the United Kingdom presented a study which appeared to link high levels of dieldrin to breast cancer (Hoyer, et al., 1998). This not only illustrates the carcinogenic nature of these compounds but highlights the potential link of certain Level I pesticides to disruption of the endocrine system, which is currently being debated. Table 4-10 summarizes the potential health effects associated with the pesticides.

**Table 4-10. Potential Human Health Effects Associated with Level I Pesticides<sup>a</sup>**

Chemical	Cancer	Reproductive/ Developmental	Neurological/ Behavioral	Immunological	Endocrine	Other Non-Cancer
Aldrin	Probable		X			
Chlordane	Probable	X	X	X	X	Liver toxicity
Dieldrin	Probable	X	X	X	X	Death
DDT	Probable	X	X	X	X	Liver toxicity
Mirex	Probable	X			X	
Toxaphene	Probable	X	X	X	X	Cardiovascular effects; liver toxicity

<sup>a</sup>Data for mirex and aldrin from USDHHS, 1995 and 1993, respectively. Data for all other chemicals from USEPA, 1997d.

In wildlife, chronic exposures to the Level I pesticides have been linked to a broad range of effects at the individual and species level including impairment of the reproductive, nervous, immune, and endocrine systems, and changes in enzyme functioning (Table 4-11; EPA, 1997d). Reproductive effects observed include reduced fertility, increased embryo toxicity, reduced hatchability, reduced survival of offspring, abnormalities in offspring, parental behavior change and changes in mating behavior (Ritter et al., 1995; EPA, 1997d). One well known example of impaired reproductive success is the association of eggshell thinning in a number of bird species with exposures to DDT and DDE. As a result of eggshell thinning, the reproductive success of these birds is greatly reduced. This effect is primarily associated with birds of prey (EPA, 1997d; Ritter et al., 1995). Table 4-12 summarizes relevant toxicity and environmental data associated with acute exposures to these chemicals.

**Table 4-11. Potential Effects of Level I Pesticides on Aquatic Life and Wildlife<sup>a</sup>.**

Chemical	Cancer	Reproductive/ Developmental	Neurological/ Behavioral	Metabolic/ Enzyme	Immunological	Decreased Growth/ Biomass	Mortality
Aldrin						P	F,B
Chlordane	M	I,F,A,B,M	F,B,M	I,M	M	I,M	I,F,A,B,M
Dieldrin		A	B				B
DDT		I,B,A,M	F,B	I,M	M	P	P,I
Mirex		M,B				M	I,B
Toxaphene	M	I,F,B,M	A,F,B			I,F,B	I,F,A,B,M

<sup>a</sup>Data for mirex and aldrin USDHHS, 1995 and 1993, respectively. Data for all other chemicals from USEPA, 1997d.

P: plants; I: invertebrates; F: fish; A: amphibians/reptiles; B: birds; M: mammals.

**Table 4-12. Summary of Relevant Toxicity and Environmental Data<sup>a</sup>.**

Chemical	Aquatic LC <sub>50</sub> (µg/L) <sup>a</sup>	Mammalian Oral LD <sub>50</sub> (mg/kg body weight)	Avian Oral LD <sub>50</sub> (mg/kg body weight)	Bioconcentration Factor	Half-Life in Soil	Half-Life in Atmosphere
Aldrin	1.3 - 89	33 - 320	6.6 - 520	1550 - 20000	Several months	35 minutes
Chlordane	0.4 - 52	335 - 1720	1200	200 - 18500	Up to 20 years	1.3 days
Dieldrin	0.5 - 330	37 - 330	26.6 - 381	4860 - 14500	1 month to 5 years	Unknown
DDT	0.4 - 380	113 - 1770	386 - 2240	12000	2 - 15 years	2 days
Mirex	NA	125 - 1000	1400 - 10000	2600 - 51400	Up to 10 years	Unknown
Toxaphene	2.2 - 21	46 - 365	70.7 - 250	4200 - 90000	2 months to 11 years	4 - 5 days

<sup>a</sup>Represents 96 hours LC<sub>50</sub> for fish and invertebrate species.

Sources: Ritter et al., 1995 and USDHHS Reports.

In addition to the effects noted above, chlordane, dieldrin, DDT, and toxaphene are believed to be endocrine disruptors (USEPA, 1997d; Ritter et al., 1995). Endocrine disruptors are chemicals that are believed to interfere with the operation of the endocrine system in many ways, including mimicking or blocking the effect of natural hormones. This interference can potentially disrupt the reproductive and immune systems and adversely affect metabolism, growth and behavior. For example, p,p-DDE has been shown to inhibit the binding of androgen, and has been associated with effects such as reduced penis size in alligators (USEPA, 1997d). In laboratory studies, DDT has been shown to induce production of vitellogenin, a protein typically produced only in females, in male turtles and frogs (EPA, 1997).

#### ***4.3.2 Current Human Health and Environmental Criteria and their Relevance***

To evaluate the potential adverse environmental effects that residual concentrations of the Level I pesticides may impose, available water concentration data for the Great Lakes were compared to National and Great Lakes water quality standards. Measured water concentrations in the five Great Lakes are shown on Table 4-13 in comparison with the water quality criteria for three programs:

Drinking water regulations

Water Quality Guidance for the Great Lakes System 40 CFR 132

National water quality standards under 40 CFR 131

Ambient water concentrations that exceed one of the water quality criteria are highlighted in pink.

Water quality criteria that are exceeded in one or more of the Great Lakes are highlighted in blue.

The water column data found and shown in Table 4-13 is limited. Most measurements were made in the 1980's and early 1990's. The quality of the data is generally good based upon the summaries provided in the published literature. However, DDT concentrations reported in Hoff et al, 1996 for all Lakes are unpublished and were obtained by personal communication, therefore the quality is unknown. In addition, the majority of the results reported here were made on whole water samples, although some data were collected as the dissolved fraction using either filtration or centrifugation. Because most of the samples were collected offshore, suspended particulate loads were low and total and dissolved concentrations would not be expected to be very different.

### ***Drinking Water Regulations***

The concentrations shown in the “Drinking Water Regulations” line of Table 4-13 are reviewed semi-annually by the U.S. Environmental Protection Agency Office of Water, Office of Science and Technology. The Maximum Contaminant Level (MCL) is the maximum permissible level of a contaminant in water delivered to users of a public water system. Health Advisories (HA's) provide information on contaminants that can cause human health effects and are known to occur or are anticipated to occur in drinking water. MCLs have been published for chlordane and toxaphene, while HA's have been issued for aldrin and dieldrin. The MCL for chlordane of 2,000 ng/l was set based upon liver or nervous system problems and increased risk of cancer. The MCL for toxaphene of 3,000 ng/l was set based upon kidney, liver or thyroid problems and increased risk of cancer. The HA's for aldrin and dieldrin have been set at 200 ng/l based upon a calculated increased cancer risk of  $10^{-4}$ .

The measured concentrations shown for the Great Lakes are from 260 to several thousand times lower than the MCL or HA levels for the level I pesticides; hence, the consumption of drinking water does not pose a threat based upon the drinking water standards.

### ***Great Lakes Water Quality Guidance***

Water quality criteria (WQC) derived specifically for the Great Lakes were promulgated in 1995 as the “Final Water Quality Guidance for the Great Lakes System; Final Rule,” (60 *FR* 15366) (Guidance). At the time of promulgation USEPA included specific numeric WQC for a set of chemicals that were also listed in 40 CFR Part 132; the WQC from the Guidance are also shown on Table 4-13. The Guidance further establishes methodologies to be used by the States and Tribes to derive additional human health WQC based on carcinogenic and non-carcinogenic responses, wildlife WQC, and aquatic life WQC in the Great Lakes basin. Because the Level I pesticides bioaccumulate in fish to concentrations several orders of magnitude above ambient water concentrations, the WQC derived to be protective of exposures associated with the consumption of fish and water are lower than the values derived for the consumption of water alone. The accumulation of toxicants in fish from dietary sources as well as direct uptake from the water are considered in developing the Guidance for human health and wildlife WQC. The human health cancer criteria published in the Guidance are based upon a cancer risk of  $10^{-5}$  (several states are applying a risk of  $10^{-6}$ ) which results in some of the WQC being below

the detectable limits associated with the analytical methods used by recent investigators.

Guidance WQC for human “non-carcinogenic” effects for the Level I pesticides are generally higher than the carcinogenic WQC; most Lake concentrations are below the non-carcinogenic WQC with the exception that one dieldrin concentration measurement for Lake Erie exceeds the “non-carcinogenic” human health WQC. The human health “carcinogenic” WQC are significantly lower, and the latest concentrations for Lakes Superior, Erie and Ontario exceed these criteria for dieldrin and DDT, while the human health carcinogenic WQC for toxaphene is exceeded in all five Great Lakes.

Aquatic Life guidelines are only published for dieldrin. Present concentrations in the Lakes are well below the guideline value of 56 ng/l for chronic risk.

There is only one wildlife guideline published for DDT at 0.011 ng/l. The latest concentrations measured for Lakes Superior, Erie and Ontario exceed this value, indicating that fish eating wildlife may still be affected by residual DDT concentrations.

### ***Water Quality Standards***

Water Quality Standards (WQSs) are developed by states and tribes using EPA guidance and under EPA oversight (40 CFR Part 131) under Section 304(a) of the Clean Water Act. The human health WQC typically consider that fish achieve toxicant levels only from the water due to direct exposure to the water column. The National WQC for human health protection are higher than human health concentration guidelines under the Great Lakes Guidance.

However, the chronic WQC for protection of aquatic life under the National WQS are lower than aquatic life protection values under the Great Lakes WQC. These goals are exceeded only by toxaphene in Lakes Superior, Michigan and Huron.

WQC to protect wildlife have not been developed under Section 304(a) of the Clean Water Act.

### ***Conclusions for Human Health and Wildlife***

The latest measured concentrations of Level I pesticides in the Great Lakes are at least several hundred times lower than published drinking water standards or advisories. Hence, the Level I pesticides do not cause impairment of drinking water.

Also, Great Lakes surface waters are below levels calculated to impose risk to aquatic receptors with one exception; toxaphene concentrations in Lakes Huron, Michigan and Superior are above the WQS goal for protection of aquatic life under continuous exposure conditions.

Fish eating wildlife may still be impacted by DDT in Lakes Erie and Ontario and perhaps Lake Superior.

Human health is impacted mostly through the consumption of fish, and concentrations of DDT, dieldrin

and toxaphene in most of the Lake Waters exceed the Water Quality Guidelines for the Great Lakes. This is further manifested in the recommended restrictions on the consumption of fish from the Great Lakes (fish consumption advisories).

**Table 4-13. Comparison of Water Concentrations (ng/L) to Great Lakes and National Water Quality Guidelines and Criteria.**

		– YEAR	Aldrin	Dieldrin	Chlordane	DDT	Mirex	Toxaphene
	(Concentration in ng/L)							
Measured Concentrations	Lake Superior	>1996	<0.007 <sup>a</sup>	0.07-0.16 <sup>a</sup>	0.0079 <sup>i</sup>	0.006 <sup>i</sup>	<0.0005 <sup>i</sup>	NA
		<1994	0.044-0.359 <sup>b</sup>	0.08-0.412 <sup>b,c</sup>	0.06-0.3 <sup>b</sup>	0.007-0.195 <sup>b,c</sup>	NA	0.29-1.12 <sup>e</sup>
	Lake Michigan	>1990	NA	NA	0.027 <sup>i</sup>	0.039 <sup>i</sup>	<0.0005 <sup>i</sup>	0.13-0.38 <sup>e</sup>
		<1990	NA	NA	NA	NA	NA	NA
	Lake Huron	>1990	NA	NA	0.012 <sup>i</sup>	0.014 <sup>i</sup>	<0.0005 <sup>i</sup>	0.16-0.47 <sup>e</sup>
		<1990	<0.01 <sup>f</sup>	0.2-0.4 <sup>c,f</sup>	0.004-0.07 <sup>b,d,f</sup>	0.002-0.15 <sup>b,d,f</sup>	<0.04-1.1 <sup>f,g</sup>	NA
	Lake Erie	>1990	<0.01 <sup>h</sup>	0.06-0.76 <sup>h</sup>	0.026 <sup>j</sup>	0.063 <sup>i</sup>	<0.0005 <sup>i</sup>	0.079-0.23 <sup>e</sup>
		<1990	<0.01 <sup>f</sup>	0.2-1.1 <sup>c,f</sup>	0.06-0.1 <sup>f</sup>	0.007-0.022 <sup>b</sup>	<0.04-1.4 <sup>f,g</sup>	NA
	Lake Ontario	>1990	<0.01 <sup>h</sup>	0.12-0.27 <sup>h</sup>	0.0147 <sup>i</sup>	0.043 <sup>i</sup>	0.0027 <sup>i</sup>	0.061-0.17 <sup>e</sup>
		<1990	<0.01 <sup>f</sup>	0.1-0.63 <sup>b,c,f</sup>	0.008-0.06 <sup>b,f</sup>	0.02-0.05 <sup>b</sup>	<0.04-1.5 <sup>f,g</sup>	NA
Drinking Water Regulations: MCL or HA <sup>5</sup>			200 (HA)	200 (HA)	2,000 (MCL)			3,000 (MCL)
Great Lakes Initiative Guidelines and Criteria <sup>1,2</sup>  40 CFR 132.6	Human Carcinogenic		NA	0.0065	0.25	0.15	NA	0.068
	Human Noncarcinogenic		NA	0.41	1.4	2	NA	NA
	Aquatic Life	Acute	NA	240	NA	NA	NA	NA
		Chronic	NA	56	NA	NA	NA	NA
	Wildlife		NA	NA	NA	0.011	NA	NA
National WQS <sup>3,4</sup>  40 CFR 131	Aquatic Life	Freshwater Continuous	–	1.9	4.3	1	NA	0.2
		Freshwater Maximum	3,000	2,500	2,400	1,100	NA	730
		Saltwater Continuous	–	1.9	4	1	NA	0.2
		Saltwater Maximum	1,300	710	90	130	NA	210
	Human Health		0.13	0.14	0.57	0.59	NA	0.73

**Table 4-13. Comparison of Water Concentrations (ng/L) to Great Lakes and National Water Quality Guidelines and Criteria (Continued).**

		– YEAR	Aldrin	Dieldrin	Chlordane	DDT	Mirex	Toxaphene
(Concentration in ng/L)								
State Standards: Indiana Department of Environmental Management (IDEM)	Aquatic Life	Acute	150			450		
		Chronic	35			32		
	Human Health		2.4 ×10 <sup>-3</sup> (noncancer) fish ingestion and fish/water ingestion					
State Standards: Michigan Department of Environmental Quality (MDEQ)	Aquatic Life	Acute			270	29		150
		Chronic			29	3.2		5
	Wildlife			0.071				0.14
	Human Health							21 (noncancer) fish ingestion and fish/water ingestion

NA = Not Available

1. USEPA, 1995. March 23, 1995 Great Lakes Initiative
2. Great Lakes Water Quality Agreement, 1987.
3. USEPA, 1997e. Water Quality Standards, 40 CFR 131.
4. Values are for human chronic exposure through both fish consumption and drinking water at a 10<sup>-6</sup> risk level.
5. USEPA Drinking Water Regulations and Health Advisories (<http://www.epa.gov/OST/Tools/dwstds1.html>)

*Sources:*

<sup>a</sup>L'Italian1998

<sup>b</sup>Stevens and Neilson 1989

<sup>c</sup>Hoff et al., 1996

<sup>d</sup>USEPA, 1997d

<sup>e</sup>Swackhamer et al., 1998

<sup>f</sup>L'Italian 1993

<sup>g</sup>Sergeant et al., 1993

<sup>h</sup>L'Italian, 1996a; 1996b

<sup>i</sup>Unpublished data from USEPA Great Lakes National Program Office, 1997.

### **Sediment Quality Effects Evaluation**

Currently, there are no sediment quality criteria that have been developed specifically for the Great Lakes. Therefore, in the absence of national or regional benchmark values for the Level I pesticides, three alternative sets of toxicity values were evaluated, including sediment screening values developed by NOAA (Long and Morgan, 1991), national sediment quality criteria (SQC) proposed by Environment Canada (Environment Canada, 1994) and Provincial SQC adopted by the Province of Ontario (Persaud, et al., 1993) (Table 4-14). All of these values were derived for the protection of aquatic species.

NOAA's (Long and Morgan, 1991) effects range-low (ER-L) and effects range median (ER-M) values were statistically derived based on a distribution of all concentrations reported to be associated with any adverse effects in aquatic species. The ER-L is the 10th percentile of this distribution, and is intended to represent the lowest value at which effects are possible. The ER-M is the 50th percentile and is intended to indicate the lowest value at which effects are likely to occur (i.e., probable effects concentration). In general, concentrations lower than the ER-L are generally protective of all aquatic species, while effects are considered probable for sediments where concentrations exceed the ER-M (Long and Morgan, 1991).

Interim sediment quality assessment values proposed as national sediment quality guidelines for Canada were also included (Environment Canada, 1994). These values were derived using a modified version of the approach used to calculate the NOAA values. In this methodology, literature on each chemical was divided into effects and no effects data sets. The threshold effect level (TEL) represents the geometric mean of the 15<sup>th</sup> percentile concentration of the effects data set and the 50<sup>th</sup> percentile concentration of the no effects data set. The probable effect level (PEL) is the geometric mean of the 50<sup>th</sup> percentile of the effects data set and the 85<sup>th</sup> percentile of the no effects data set. Thus, concentrations below the TEL are not expected to be associated with effects, while exceedance of the PEL indicates probable effects (Environment Canada, 1994).

In addition, guidelines developed by the Province of Ontario in Canada were considered. Ontario's guidelines define three levels of effects, the no effect level (NEL), lowest effect level (LEL) and the severe effect level (SEL) (Persaud, et al., 1993). The NEL represents concentrations at which no effects have been observed and is intended to protect all aquatic resources against toxicity and biomagnification. The LEL is intended to protect the majority of the benthic community, while the SEL indicates a level at which pronounced disturbance of the sediment-dwelling community can be expected (Persaud, et al., 1993). The NEL is derived using an equilibrium partitioning (EqP) approach, while the LEL and SEL are calculated using a screening-level concentration (SLC) approach (Persaud, et al., 1993).

In general, concentrations of the pesticides measured in surficial sediments exceeded the minimum guidelines available. For example, concentrations of aldrin, dieldrin, chlordane, DDT and mirex all exceeded the values representing the ER-L (Long and Morgan, 1991), the LEL

**Table 4-14. Comparison of Measured Sediment Levels to Relevant Sediment Quality Guidelines.**

		Aldrin <sup>a</sup>	Dieldrin <sup>a</sup>	Chlordane	DDT	Mirex <sup>a</sup>	Toxaphene
	(Concentrations in µg/kg)						
Measured Concentrations	All Lakes	1	5	0.5 - 310	3.0-50	ND - 25	2.8 - 45
	Lake Superior	NA	NA	NA	3	NA	2.8 - 15
	Lake Michigan	1	5	0.5 - 4	50	ND	15 - 45
	Lake Ontario	NA	NA	NA	50	25	15 - 16
Ontario Ministry of the Environment Sediment Quality Criteria <sup>b</sup>	NEL	NA	0.0006	0.005	NA	NA	NA
	LEL <sup>c</sup>	0.002	0.002	0.007	0.007	0.007	NA
	SEL <sup>d</sup>	8.4	91	6	12	130	NA
NOAA Benchmark Guidelines <sup>e</sup>	ER-L	NA	0.02	0.5	3	NA	NA
	ER-M	NA	8	6	350	NA	NA
Environment Canada Proposed National Sediment Quality Criteria <sup>f</sup>	TEL	NA	0.715	2.26	3.89	NA	NA
	PEL	NA	4.3	4.79	51.7	NA	NA

NA = Not Available

ND = Below Detection Limits

<sup>a</sup> Current measured concentrations estimated based on depth profile graphs.

<sup>b</sup> (Persaud, et al., 1993) No-effect level (NEL), lowest effect level (LEL), and severe effect level (SEL).

<sup>c</sup> Assumes 1% organic carbon.

<sup>d</sup> Guideline is presented in units of µg/g organic carbon.

<sup>e</sup> Long and Morgan, 1991. Effects Range-Low (ER-L) and Effects Range-Median (ER-M).

<sup>f</sup> Environment Canada, 1994. Threshold effect level (TEL) and Probable Effect Level (PEL).

 Criteria Exceeded

(Persaud, et al., 1993) and the TEL (Environment Canada, 1994). However, only chlordane, dieldrin and DDT were reported at concentrations that exceed the guidelines associated with probable or severe effects (i.e., ER-M, PEL, SEL). Maximum reported concentrations of chlordane exceed all of the available guidelines by a relatively large margin while maximum reported concentrations of DDT exceed the severe effect level derived by Ontario (Persaud, et al., 1993), but are approximately equivalent to the PEL (Environment Canada, 1994) and below the ER-M (Long and Morgan, 1991). In contrast, dieldrin exceeds only the PEL (Environment Canada, 1994) in Lake Michigan. Historically, concentrations of each of these pesticides were higher, and were likely associated with an increased potential for adverse effects.

It is important to note that exceedance of these criteria does not mean that adverse effects have occurred; rather, it is an indication that the potential for impacts to the aquatic community exist. The guidelines evaluated are based on effects data associated with a variety of impacts including mortality, developmental effects, reduced growth, and reductions in reproductive success.

### **Biota**

In addition to sediment and water, benchmark guidelines have also been developed for concentrations of pesticides in fish and other biota tissues (e.g., eggs). Typically these concentrations have been derived for the purpose of protecting piscivorous species (i.e., humans or wildlife). Table 4-15 presents the benchmark guidelines identified.

Comparison of recently measured fish tissue levels to benchmark values for human health indicates that concentrations of all of the chemicals except toxaphene exceed at least one of the available criteria (Table 4-15). This suggests that consumption of fish from the Great Lakes continues to pose a potential risk to humans. Eating fish is one of the most common exposure routes for humans to environmental contaminants. Therefore, fish consumption advisories are frequently issued by regulatory agencies as a result of elevated concentrations of chemicals in fish tissue. As a result, fish consumption advisories provide concrete examples of health concerns and the effects that chemicals have on the public use of waters and aquatic resources (USEPA, 1997d).

In the Great Lakes region, most fish consumption advisories that have been issued are driven by elevated concentrations of PCBs, although other pollutants such as mercury, chlordane, and dioxin have also warranted fish advisories in many waterbodies (EPA, 1997d). Table 4-16 lists fish consumption advisories in the Great Lakes region that have been issued as the result of these pesticides (State of Michigan, 1999)

Concentrations of DDT were found to exceed the available benchmark guidelines derived for the protection of piscivorous wildlife, indicating that potential risks to fish-eating birds and mammals may also still exist. The only other chemicals for which criteria exist were dieldrin and aldrin; the combined concentrations of those chemicals appear to be below the relevant benchmark values. One guideline value for concentrations in avian eggs was also evaluated. Environment Canada suggests a value of 1 ppm DDT in bird eggs based on available toxicity data. Current concentrations of DDT reported in eggs are slightly below this concentration, indicating that potential risks have been reduced.

**Table 4-15. Comparison of Measured Biota Concentrations to Relevant Guidelines.**

FISH TISSUE (mg/kg)							
		Aldrin	Dieldrin	Chlordane	DDT	Mirex	Toxaphene
Maximum Measured Concentration from 1988 and above -all species (CMA, 1997)	All Lakes	NA	0.045 - 0.2	0.01 - 0.11	0.19-1.5	not detected -0.18	NA
	Lake Superior	NA	0.045	not detected	0.35	not detected	NA
	Lake Huron	NA	NA	0.01	0.8	NA	NA
	Lake Erie	NA	0.07	not detected	0.19	not detected	NA
	Lake Michigan	NA	0.2	0.11	1.5	NA	NA
	Lake Ontario	NA	0.12	0.03	1.2	0.18	NA
Human Health Guidelines	LaMP, 1998 <sup>a</sup>	NA	NA	0.037	NA	NA	NA
	Great Lakes Initiative <sup>b</sup>	NA	0.0025	0.04	NA	NA	NA
	USFDA <sup>c</sup>	sum of aldrin and dieldrin cannot exceed 0.3		0.3 <sup>d</sup>	5	0.1	5
	Health Canada <sup>e</sup>	NA	NA	NA	5	0.1	NA
	Great Lakes Water Quality Agreement <sup>f</sup>	sum of aldrin and dieldrin cannot exceed 0.3		NA	NA	NA	NA
Wildlife Guidelines	Great Lakes Water Quality Agreement <sup>g</sup>	NA	NA	NA	1	NA	NA
	International Joint Commission <sup>h</sup>	sum of aldrin and dieldrin cannot exceed 0.3		NA	1	less than detection	NA

**Table 4-15 (continued)**

AVIAN EGGS (mg/kg)							
		Aldrin	Dieldrin	Chlordane	DDT	Mirex	Toxaphene
	All Lakes	NA	0.11 - 0.45	<0.1	<10	<0.1	NA
Maximum Measured Concentrations from 1988 and above - all species (CMA, 1997)	Lake Superior	NA	0.45	<0.1	<5	<0.1	NA
	Lake Huron	NA	0.2	<0.05	<5	<0.1	NA
	Lake Erie	NA	0.14	<0.1	<7	<0.1	NA
	Lake Michigan	NA	0.3	<0.1	<10	<0.1	NA
	Lake Ontario	NA	0.11	<0.1	<5	<0.1	NA
Guidelines	Environment Canada, 1997 <sup>i</sup>	NA	1	NA	NA	NA	NA

\* Measured concentrations were taken from Chemical Manufacturers Association, 1997. These concentrations represent the maximum reported concentration for the listed chemicals for years post 1988. NA = no data are reported for a particular chemical.

<sup>a</sup> Fish Tissue criteria for protection of human health reported in the Lake Ontario LaMP, May, 1998.

<sup>b</sup> GLI Fish Flesh Values, based on 3.1% lipid content. From Lake Ontario LaMP, May 1998.

<sup>c</sup> US Food and Drug Administration action levels in edible portions of fish. As reported by USEPA, 1995 unless otherwise noted.

<sup>d</sup> US Food and Drug Administration action levels in edible portions of fish. FDA, 1990 as cited by USDHHS 1994a.

<sup>e</sup> Health Canada consumption guidelines for edible portions of fish (USEPA, 1995).

<sup>f</sup> Great Lakes Water Quality Agreement, 1987 for the protection of human consumers of fish.

<sup>g</sup> Great Lakes Water Quality Agreement, 1987 for the protection of piscivorous birds.

<sup>h</sup> International Joint Commission objectives for protection of wildlife (USEPA, 1995).

<sup>i</sup> As reported in the Lake Ontario LaMP, May 1998.

**Table 4-16. Fish Consumption Advisories in the Great Lakes Region.**

Population	Contaminant	Fish	Size	Advisory
Lake Erie				
General	PCBs	carp, catfish	all	do not eat these fish
	PCBs	chinook coho, drum, lake trout, rainbow trout, smallmouth bass, walleye, white bass, white perch, yellow perch	all	unlimited consumption
	PCBs and Dioxins	whitefish	>22"	do not eat these fish
Women and Children	PCBs	carp, catfish,	all	do not eat these fish
	PCBs	chinook, coho, rainbow trout, smallmouth bass, white bass, white perch	all	one meal per month
	PCBs	lake trout	all	six meals per year
	PCBs	walleye	< 22"	one meal per week
			>22"	one meal per month
	PCBs	yellow perch	all	one meal per week
	PCBs and Dioxins	whitefish	all	do not eat these fish
Lake Huron				
General	PCBs	burbot, chinook, coho, rainbow trout	all	unlimited consumption
	PCBs	brown trout	>18"	one meal per week
	PCBs, Chlordane, Dioxins	lake trout	<22"	one meal per week
			>22"	do not eat these fish
	PCBs,Dioxins	whitefish	>22"	do not eat these fish
Women and Children	PCBs	burbot	all	one meal per week
	PCBs, Chlordane, Dioxins	lake trout	all	do not eat these fish
	PCBs	rainbow trout,coho	all	one meal per month
	PCBs	chinook	<30"	one meal per month
			>30"	six meals per year
	PCBs	brown trout	<18"	one meal per month
			>18"	do not eat these fish
	PCBs, dioxins	whitefish	<18"	one meal per week
			18-22"	one meal per month
			>22"	do not eat these fish
Lake Michigan				
General	PCBs	carp, catfish	all	do not eat these fish
	PCBs, Chlordane, Dioxins	whitefish	<14"	one meal per week
			>14"	do not eat these fish
	PCBs	chinook, coho, rainbow trout, smelt, yellow perch	all	unlimited consumption
	PCBs	brown trout	<22"	unlimited consumption
			>22"	do not eat these fish
PCBs, Chlordane	lake trout	<26"	unlimited consumption	

Population	Contaminant	Fish	Size	Advisory
			>26"	one meal per week
	PCBs, mercury	walleye	<22"	unlimited consumption
			>22"	one meal per week
	PCBs	sturgeon	all	do not eat these fish

**Table 4-16. (continued)**

Population	Contaminant	Fish	Size	Advisory
Women and Children	PCBs, Chlordane, Dioxins	carp, catfish, whitefish	all	do not eat these fish
	PCBs	smelt, yellow perch	all	one meal per week
	PCBs	chinook, coho	>26"	one meal per month
	PCBs	brown trout	<22"	one meal per month
			>22"	do not eat these fish
	PCBs, Chlordane	lake trout	<26"	one meal per month
			>26"	six meals per year
	PCBs	rainbow trout	<18"	one meal per week
			>18"	one meal per month
	PCBs, mercury	walleye	18-26"	one meal per month
			>26"	six meals per year
	PCBs	sturgeon	all	do not eat these fish
<b>Lake Superior</b>				
General	PCBs	brown trout, chinook, coho, lake herring, whitefish	all	unlimited consumption
	PCBs, chlordane	lake trout	<18"	unlimited consumption
			18-30"	one meal per week
			>30"	do not eat these fish
	PCBs, Chlordane, Dioxins, Mercury	ciscowet	<18"	unlimited consumption
			>18"	do not eat these fish
Women and Children	PCBs	brown trout, coho, lake herring, whitefish	all	one meal per week
	PCBs	chinook	<22"	one meal per week
			>22"	one meal per month
	PCBs, Chlordane	lake trout	<18"	one meal per week
			>18"	do not eat these fish
	PCBs, Chlordane, Dioxins, Mercury	ciscowet	<18"	six meals per year
			>18"	do not eat these fish

Source: State of Michigan, 1999.

#### 4.4 Waste Pesticide Collections (Clean Sweeps)

While all Level I pesticides have been canceled, stockpiles of these substances remain. Various waste pesticide collection programs have been developed and operated by the states in an attempt to collect the remaining stockpiles of these and other hazardous substances. These programs are often referred to as "Clean Sweeps" Programs. The purpose of the Clean Sweeps Programs is to promote easy and non-threatening collection of unwanted, canceled, or hazardous agricultural chemicals for appropriate disposal. Individual states have implemented their own Clean Sweeps Programs, which are funded by

state and federal dollars. Each of the states bordering the Great Lakes conducts periodic collection events or operates a year-round facility to collect hazardous agricultural chemicals.

It should be noted that there are limitations to the quality of the waste pesticide collection data available for this draft report. The state data are incomplete and subject to change. Collection data by year was only available for the total amount of pesticides collected, not the amount of each Level I pesticide. Nevertheless, the data does provide evidence that significant quantities of unused stocks of these substances have been available for collection as discussed below.

#### ***4.4.1 Total Pesticides Collected***

Clean Sweeps collection events conducted from 1990 to 1997 in the Great Lakes states (Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, New York, and Minnesota) yielded at least 4 million pounds of pesticides (Table 4-17). Minnesota, which uses pesticide registration fees to fund their Clean Sweeps Program, had the highest volume of pesticides collected. Minnesota, Michigan, Ohio, Pennsylvania, and Wisconsin all have collected over 500,000 pounds of pesticides since 1990. The smallest volume of pesticides was collected in New York, which appeared to have only operated their program in 1993 and 1994.

It is difficult to assess trends in the amount of pesticides collected since 1990 in Clean Sweeps Programs. There is no basis to assume that differences in the amount collected from year to year (or state to state for that matter) are a reflection of the total stockpile of pesticide available, since the amount collected is dependent on many factors. For example, the participation and volume of pesticides collected may have been related to the cost to participants or the source of funding for each state's program. The state-wide programs that were the most successful, in terms of volume of pesticides collected, were Wisconsin and Ohio. The Ohio program was free to participants. The Clean Sweeps Program in Wisconsin, which targeted farmers and agricultural businesses, had multiple mechanisms (including pesticide registration fees) for funding the program. Minnesota and Pennsylvania were the only states whose program was primarily funded by pesticide registration fees. Other states' Clean Sweeps Programs appeared to be supported by inconsistent sources of funding, which may have impacted the program's success (i.e., number of participants and volume of pesticides collected). Other factors that may affect data for a given state include limitations on the maximum amount that could be collected and disposed of in a given time period, quality of record keeping, etc.

Nevertheless, the data in Table 4-17, which were taken from a survey of all states, provides some information about collection of total pesticides over time and across regions. First, the amounts collected are NOT decreasing dramatically over time. In fact, 1996 or 1997 represents the greatest quantity of pesticides collected over the eight year time span for Minnesota, Ohio, Pennsylvania, and Wisconsin. In addition, significant quantities were collected by many states.



**Table 4-17. Weight of Pesticides Collected During 1990 to 1997 by Great Lakes States.**

State	Pesticide Volume (pounds) <sup>a</sup>								
	1990	1991	1992	1993	1994	1995	1996	1997	Total
Illinois	30,900	6,500	NA	137,000	NA	NA	NA	NA	174,400 <sup>b</sup>
Indiana	8,800	NA	43,000	6,000	9,000	8,100	1,900	4,309	81,109 <sup>b</sup>
Michigan <sup>c</sup>	84,000	84,000	64,000	84,000	84,000	60,000	NA	49,400	509,400 <sup>b</sup>
Minnesota	66,100	36,000	54,000	132,000	182,000	171,000	196,000	282,000	1,119,100
New York	-	-	-	8,300	NA	-	-	-	8,300 <sup>b</sup>
Ohio	-	-	-	9,000	113,000	126,000	251,300	174,600	673,900
Pennsylvania	-	-	NA	29,700	60,100	82,100	300,300	174,000	646,200 <sup>b</sup>
Wisconsin	39,100	9,622	84,200	143,558	107,526	158,087	172,034	NA	714,127 <sup>b</sup>
Total All Great Lakes States									3,926,536

<sup>a</sup> Based upon surveys of all states by U.S. EPA Office of Pesticide Programs.

<sup>b</sup> Total assumes the minimum amount since data not available (na) for all years.

<sup>c</sup> Collected 64,000 pounds in 1992. Assumed the remainder of the 400,000 pounds collected from 1990 through 1994 was evenly distributed among the four years, i.e., 84,000 pounds per year.

#### 4.4.2 Level I Pesticides Collected

More than 40,000 kgs of Level I pesticides have been collected during Clean Sweeps Programs conducted by the Great Lakes states from 1992 to 1998 (Table 4-18). More than 50% of the total pounds of pesticide collected was DDT.

As with the total pesticides collected, it does not appear that collection of significant quantities of the Level I pesticides was limited to any particular state. From the current available data, it is not possible to assess the degree to which significant quantities have continued to be collected in the most recent years.

**Table 4-18. Clean Sweep Collections of BNS Level I Pesticides in the Great Lakes Drainage Basin (1990-98).**

State	Dates of Collection	Substances Collected - Kgs <sup>a</sup>							
		Aldrin	Chlordane	DDT	Dieldrin	Mirex	Toxaphene	Total Level I Pesticide	Total All Substances (90-98)
Illinois	1994-98	35	397	85	4	0	0	521	62,132
Indiana	1992-97	68	104	177	2	0	5	356	19,637
Michigan	1992, 94, 95	1,913	2,743	3,951	913	0	315	9,835	297,052
Minnesota	1990-98	0	272	5,714	0	0	91	6,077	634,920
Ohio	1993-98	1,980	2,909	4,580	431	0	604	10,504	349,887
Wisconsin <sup>b</sup>	1993-96	157	554	1,910	99	0	271	2,991	Incl Below
Wisconsin	1997	66	383	5,938	91	0	27	6,505	498,866
New York <sup>c</sup>	1993, 95, 96	-	509	3,305	-	-	-	3,814	82,247
Pennsylvania	1995-97	0	17	387	13	0	227	644	293,061
Total (each substance)		4,219	7,888	26,047	1,553	0	1,540	41,247	2,237,802

<sup>a</sup> Based on reports and communications from states as of 11/16/98; compiled by Margaret L. Jones, U.S. EPA Region 5. Some data are estimates, and may be revised up or down with more complete analysis.

<sup>b</sup> Great Lakes Basin collections not isolated for these years. Basin collections roughly estimated at 1/3 of state.

<sup>c</sup> New York identified the entire organochlorine group as DDT, and the chlorinated cyclodienes as Chlordane.

#### ***4.4.3 Comparison of Clean Sweeps Collections to Current Great Lakes Water Column Loadings***

The significance of the amount of Level 1 pesticides collected in Clean Sweeps becomes apparent when the amount collected is compared to the estimated total amounts currently in the Great Lakes. Table 4-19 presents estimates of the total amount of pesticides in each lake along with currently available recorded estimates of the amount collected in Clean Sweeps Programs. Examination of the table reveals that, with the exception of toxaphene and mirex, the amount of pesticides collected in the Clean Sweeps Programs far exceeds the amount currently estimated to be in the waters of the Great Lakes. The amount collected for DDT+metabolites was 27 times the amount estimated to be in the waters of all the Great Lakes combined. The amount collected for aldrin/dieldrin and chlordane were approximately 2 and 10 times, respectively, the total Great Lakes loadings. It should also be noted that the estimated amount of pesticides collected most likely represent a conservative estimate of total amount collected since data was not available for all years. However, in spite of all the limitations of the currently available data, there is a clear indication that the Clean Sweeps Programs are reducing existing stockpiles of the

Level 1 pesticides that have potential to have a significant impact on the environment if they were not disposed of properly.

**Table 4-19. Comparison of Current (>1990) Great Lakes Water Column Loads of Level 1 Pesticides to Masses Collected in Clean Sweeps <sup>(a)</sup>.**

	Lake Superior		Lake Michigan		Lake Erie		Lake Huron		Lake Ontario		Estimated Total Pesticide Load in kgs	
Lake Volumes (Km) <sup>3</sup> —	12,100		4,920		484		3,540		1,640			
Pesticides —	Water Column Concentration (ng/L)	Total Water Column Loading (kg) <sup>(a)</sup>	Water Column Concentration (ng/L)	Total Water Column Loading (kg) <sup>(a)</sup>	Water Column Concentration (ng/L)	Total Water Column Loading (kg) <sup>(a)</sup>	Water Column Concentration (ng/L)	Total Water Column Loading (kg) <sup>(a)</sup>	Water Column Concentration (ng/L)	Total Water Column Loading (kg) <sup>(a)</sup>	Total Water Column Loading (kg) <sup>(a)</sup>	Total Clean Sweep Collections in G.L. Basin (kg) <sup>(c)</sup>
Aldrin + Dieldrin	<0.007-0.16	1936	NA	--	0.06-0.76	368	0.4	1,416	0.12-0.27	443	4,163	5,729
Chlordane	0.0079	95	0.027	133	0.026	13	0.012	43	0.0147	24	308	7,828
DDT+ Metabolites	0.006	73	0.039	192	0.063	30	0.014	51	0.043	71	417	25,845
Mirex	<0.005	61	<0.005	25	<0.005	2	<0.005	18	0.0027	4	110	0
Toxaphene	1.12	13,552	0.38	1,870	0.079-0.23	111	0.13-0.47	1,664	0.061-0.17	279	17,476	1,527
Totals		15,717		2,220		524		3,192		821	22,474	41,247

<sup>(a)</sup> Water column concentrations taken from Table 4-13.

<sup>(b)</sup> When water column concentrations are non-detected ("<" indicates not detected above the detection limit listed), ½ of the detection limit was used to calculate estimated mass; When a range of concentrations are reported, the highest concentration is used to calculate mass.

<sup>(c)</sup> Clean sweep collections include all States in the Great Lakes Basin and represent total collections between 1990 through 1998.